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Governing the gaps in water governance and land-use planning in a megacity: The example of hydrological risk in Mexico City

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ABSTRACT

Megacities are socio-ecological systems (SES) that encompass complex interactions between residents, institutions, and natural resource management. These interactions are exacerbated by climate change as resources such as water become scarce or hazardous through drought and flooding. In order to develop pathways for improved sustainability, the disparate factors that create vulnerable conditions and outcomes must be visible to decision-makers. Nevertheless, for such decision-makers to manage vulnerability effectively, they need to define the salient boundaries of the urban SES, and the relevant biophysical, technological, and socio-institutional attributes that play critical roles in vulnerability dynamics. Here we explore the problem of hydrological risk in Mexico City, where vulnerabilities to flooding and water scarcity are interconnected temporally and spatially, yet the formal and informal institutions and actors involved in the production and management of vulnerability are divided into two discrete problem domains: land-use planning and water resource management. We analyze interviews with city officials working in both domains to understand their different perspectives on the dynamics of socio-hydrological risk, including flooding and water scarcity. We find governance gaps within land-use planning and water management that lead to hydro-social risk, stemming from a failure to address informal institutions that exacerbate vulnerability to flooding and water scarcity. Mandates in both sectors are overlapping and confusing, while socio-hydrological risk is externalized to the informal domain, making it ungoverned. Integrated water management approaches that recognize and incorporate informality are needed to reduce vulnerability to water scarcity and flooding.

1. Introduction

The global population is now more urban than rural. Urbanization affects the consumption of resources within the city as well as land-use at the city's periphery. Urban vulnerability – the susceptibility of urban populations to the adverse effects of social-environmental stress and shocks – is rising as a policy concern in the face of increasing climate variability (Seto et al., 2012). Managing vulnerability to climate extremes such as drought and flooding demands understanding the complex interdependencies among the biophysical, technological, and socio-institutional attributes that are critical in city functioning, and how these attributes play out on the landscape and affect the quality of life of residents (Eakin et al., 2017). Different social actors, however, tend to have distinct perceptions of risk and often divergent understandings of the drivers, feedbacks, and outcomes of vulnerability (Morgan, Fischhoff, Bostrom, & Atman, 2001). These perceptions are reinforced by organizational culture and practice, and norms and institutional arrangements, potentially inhibiting the coordination required for effective vulnerability reduction (Pahl-Wostl, Holtz, Kastens, & Knieper, 2010).

The challenge of managing urban vulnerability is particularly evident in the domain of urban water governance. The management and governance of water in urban areas has a tendency to be characterized as a "compartmentalized" or sectoral problem, resulting in the separation of water management functions from other sectors of city governance (Banister & Widdifield, 2014; Pahl-Wostl et al., 2010; Wiek & Larson, 2012). Nevertheless, when considering the complex functionality of the urban socio-ecological system, water vulnerabilities, including scarcity and flooding, are tightly linked to other processes such as urban growth, transportation, and public health. Management rarely reflects this reality (Srinivasan, Seto, Emerson, & Gorelick, 2013). Indeed, in areas of rapid urbanization, particularly in the global

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south, it is common for poor households to be disconnected from basic services such as public water infrastructure. They also often settle in areas vulnerable to environmental risks such as flooding, demonstrating the coupling between urban development and vulnerability (Bakker, Kooy, Endah Sofiani, & Martijn, 2008; Romero-Lankao, 2010). As a consequence, the segregation of sectoral responsibilities and framing of socio-hydrological vulnerability as a purely environmental problem can potentially exacerbate risk because it avoids the socio-political reality that underlies the city fabric (Castro, 2007; Eakin et al., 2017). Vulnerability demands management across disparate "action arenas", or spaces of decision-making, social interaction and institution formation in relation to natural resource management (Eakin, Lerner, & Murtinho, 2010; Mcginnis, 2011; Ostrom, 2011).

In this paper, we use interviews with public-sector actors to explore the perceptions and priorities in terms of water management in two city management sectors of Mexico City: land-use planning and water management. We propose a modified version of the Management and Transition Framework that suggests that the perceptions of actors in terms of their responsibilities and understanding of hydrological risk are linked to an institutional framing (Pahl-Wostl et al., 2010) Our aim is to understand how these different actors view the causes, actions, and responsibilities of socio-hydrological risk, including flooding and water scarcity and how their views are linked to institutional responsibilities. Specifically, we ask the questions: How do the perceptions of the land-use planning and water management sectors differ and overlap in terms of the causes and consequences of water scarcity and flooding? What are the implications of these diverse perceptions for the management of socio-hydrological risk? We find that there is a divergence in the perceptions of the main causes of hydrological risk and vulnerability between the two sectors. More importantly, neither sector claims direct responsibility for managing hydrological risk. The result is a gap in responsibilities between the water and land-use sectors, leading to a "governance failure" and exacerbated vulnerabilities of communities found in the peripheries of the city (Bakker et al., 2008). The disconnect and mismatch between the perception and responsibilities of hydrological risk across government sectors gives cause to rethinking governance in urban socio-ecological systems.

2. Background

2.1. Urban growth in Mexico City

Urban life and water have coexisted in the Valley of Mexico since pre-colonial times (Sanders, Parsons, & Santly, 1979). The Aztecs founded their island capital, Tenochtitlan, on a flood-prone island in the Valley's shallow lakes. They built a raised platform to protect their monuments from floods, and enabled urban expansion by constructing *chinampas*: artificial islands that served as productive farms which fueled population growth (Candiani, 2014). After destroying Tenochtitlan and much of the Aztec water infrastructure in the conquest, the Spanish built their colonial capital over its ruins. They began to drain the valley's lakes to manage floods, which took 150 years to complete (*ibid*). Today, little of the original lakes remains. The city sources its water from the aquifer beneath the city and imports water from over 150 km away, pumping it 1000 m in elevation to reach the city (Delgado-Ramos, 2015; Martinez, Kralisch, Escolero, & Perevochtchikova, 2015; Tortajada & Castelán, 2003). The city also suffers from extreme subsidence (5–30 cm per year (Chaussard, Wdowinski, Cabral-Cano, & Amelung, 2014)), exacerbating flood risk and necessitating round-the-clock water pumping to drain the city (Comisión Nacional del Agua, 2010; Delgado-Ramos, 2015).

The extraction of water occurred alongside urban expansion in Mexico City, which began to intensify during the end of the 19th century and continued in an outward sprawl that persists today. Economic centralization led to a development boom in Mexico City throughout the 1950s and 60s, while the city rapidly tried to expand infrastructure to keep up with urban population growth (Davis, 1994). Demand for low-income housing led to the illegal occupation of thousands of hectares of communally-managed agricultural areas and ecologically valuable lands at the city's periphery, especially in the 1970s–80s (Aguilar & Guerrero, 2013; Cruz Rodríguez, 1995). The severe 1985 earthquake started an exodus from the heavily-damaged city center to the periphery (Ezcurra, Mazari-Hiriart, Pisanty, & Aguilar, 1999). The Mexico City Metropolitan Area currently encompasses approximately 20 million people across three states: Mexico City (9 million residents), the State of Mexico (11 million residents), and Hidalgo (100,000 residents).

Despite the uncontrolled, dramatic expansion of the city, urban authorities did not develop a comprehensive urban plan until the 1980s. Private development interests began to have an increasing effect on the city in the 1990s (Ezcurra et al., 1999). While the overall rate of urban expansion in Mexico City declined sharply in the 1990s, the southern boroughs in the urban periphery continued to grow at an accelerated rate (Aguilar, 2008). The lack of jobs, low-income housing, and access to credit to purchase land for the majority of the population in Mexico City led to an increasing number of informal settlements at the city's periphery: groupings of unplanned, residential structures built on cheap, peripheral land with insecure tenure, often lacking basic services built on land not designated for urban settlement (Aguilar & Guerrero, 2013; Aguilar & Santos, 2011). To make matters worse, many of these settlements are located in disaster-prone and ecologically-sensitive areas, including in the *Suelo de Conservación* or Conservation Zone (SC) (Aguilar, 2008; Sheinbaum Pardo, 2008). This Conservation Zone was officially established in 1992 to protect the city's watershed, and comprises 59% of the Federal District's territory, essentially the south half (Sheinbaum Pardo, 2008).The SC produces important hydrologic environmental services, and covers 57% of the aquifer recharge area for the city (Aguilar & Santos, 2011; Wigle, 2014).

While most of the urban growth in the Conservation Zone in Mexico City has been irregular (90% of an estimated 3000 ha), some is also due to legal formal settlements (Santos Cerquera, 2013). From 1993 to 2012, over 760,000 new homes were added in large housing developments on 11,000 ha of mostly *ejido* land,[1] which has been legally privatized (Salazar, 2014). Thus, while informal settlements represent most of the urbanization on ecologically sensitive conservation land in Mexico City, the total area urbanized through large housing developments in the metropolitan area is nearly four times greater. The homes in these multiple story units potentially consume more resources (i.e. water and energy) than irregular settlements, which are often on the margins of electricity and water services (Aguilar & Guerrero, 2013; Aguilar & Lopez, 2015).

In sum, urbanization in Mexico City is characterized by uneven development, wherein low-income residents, often in irregular settlements, face the greatest socio-hydrological risk, including water scarcity and flooding, and ecosystems protecting water resources are threatened. Formal urban growth with increased demand for water consumption continues to expand throughout the city and metropolitan area. Despite the barriers to providing water, including the construction of infrastructure to either extract or deliver water from neighboring states, there is continued urban growth that exerts pressure on the city's water resources.

[1] Ejidos and communal property are communally-held lands, distributed to smallholder farmers following the Mexican Revolution (1910–1920). Ejido and community members can use the land for individual cultivation, residential settlement, and communal use. The period of land reform ended in 1992 with a constitutional amendment that allows communal lands to be privatized; however, many agrarian communities have persisted
Land-titling is particularly relevant for ejidos, or communally-managed land that was distributed after the Mexican Revolution in 1920. Before the constitutional reform in 1992, ejido members could not receive title and sell their land. However, after the reform ejidos can privatize and sell their land through a titling process. Regularization is a process for previously informal settlements to gain legal status (Aguilar & Santos, 2011).

Table 1
Formal land-use management agencies.

Agency	Scale	Function
Oficina de Desarrollo Urbano Delegacional/Borough Urban Development Office	City borough	Makes zoning plans, heads the regularization commissions, must change land-use zone to "urban" to regularize a settlement
CORENA (Comisión de los Recursos Naturales de la Ciudad de México/ Natural Resources Commission of Mexico City)	Mexico City, within SEDEMA	Executes programs to regulate and coordinate the protection, development, and restoration of natural resources in the Conservation Zone
PAOT (Procuraduría Ambiental y del Ordenamiento Territorial de la Ciudad de México/The Environmental and Regional Planning Attorney General's Office)	Mexico City	Defends the rights of city residents to live in a healthy environment by monitoring the legal positions on land-use and environmental issues
SEDEMA (Secretaria de Medio Ambiente de la Ciudad de México/ Secretariat of Environment of Mexico City)	Mexico City	Leads recuperation of ecological zones when settled with borough, leads studies of environmental impact in regularization commissions
SEDUVI (Secretaria de Desarrollo Urbano y Vivenda de la Ciudad de México/Secretariat of Urban Development and Housing for Mexico City)	Mexico City	Approves delegation urban development plans, approves land-use changes in regularization commissions
CORRETT (Comisión para la Regularización de la Tenencia de la Tierra/ Commission of Regularization and Land Tenure)	National, within SEDATU	Expropriates ejidos or communal land to give land titles to settlers
DGRT (Dirección General de Regularización Territorial/Ministry of Land Regularization)	National	Grants land titles and registers properties in the public registry once the regularization commission approves
RAN (Registro Agrario Nacional/National Agrarian Registry)	National	Approves land-use plans in ejidos and communal zones, registers members' decisions to privatize their land
SEDATU (Secretaría de Desarrollo Agrario, Territorial y Urbano/National Secretariat of Agrarian, Territorial, and Urban Development)	National	Plans and administers public policy for land use; assures dignified housing; gives legality to agrarian communities; prevents human settlement in risk zones, provides assistance in natural disasters.

2.2. Land-use and water governance in Mexico City

Land use and water management in Mexico City are each governed at multiple scales by multiple agencies. Among the many agencies involved in land use, several are responsible for land titling and zoning within the city (see Table 1). The most important is the city's Secretariat of Urban Development and Housing (SEDUVI), which develops urban plans for the city as a whole and is responsible for zoning and decisions regarding large-scale real-estate developments. SEDUVI also oversees and approves local urban development plans of the 16 *delegaciones* or boroughs within the city. Other agencies are responsible for land-use management within the Conservation Zone, such as the Environmental Secretariat, SEDEMA, which protects the area from informal urban growth, and Commission of Regularization and Land Tenure (CORETT) and the National Agrarian Registry (RAN) which are responsible for land-titling and regularization of ejido and communal areas, which make up 71% of the Conservation Zone area (Gobierno del Distrito Federal, 2012).

On some lands, the authority of these agencies overlaps, which can lead to nebulous and conflicting land use rules. Fig. 1 shows the outline of 16 city boroughs in Mexico City, with conservation land (regulated by SEDEMA), informal settlements (mostly in the southern portion of the city), and areas with the highest levels of water scarcity and flooding.

Water management in Mexico City is based on an expansive network of infrastructure that pipes water in and out of the city that is managed by boroughs, the city government and the federal government (Table 2). The city water commission, SACMEX, is the main authority that troubleshoots water availability and flooding. An estimated 35% of potable water is lost through leakage (SACMEX, 2012). In terms of water delivery, SACMEX is also responsible for well maintenance and finding appropriate sites for drilling wells, which supply the majority of water for city residents (Martinez et al., 2015). The borough governments maintain local water infrastructure, report and repair smaller infrastructure failures, and provide water to households not on the potable water network through "*pipas*" or water tankers. Where Mexico City's water needs—for water sources and wastewater effluent sites—expand beyond the city's administrative boundaries (to neighboring states of Hidalgo and Mexico State), they are under the authority of CONAGUA, the federal water agency that is based in Mexico City. The watershed organization OCVAM operates within CONAGUA and oversees water use within the Mexico Basin that encompasses three political entities.

Not only do agencies within the domains of land use and water management struggle to coordinate with each other, but there is often little interaction across these domains. This is in part because of the agencies' narrowly-defined mandates, and a tendency toward reactive rather than proactive governing. Agencies that work on land use are concerned with land-use change, building location, land titles, structural quality, and in the conservation zone, environmental quality. Water management agencies are concerned with operating, maintaining, and expanding the city's water pipes and drains, managing water resources, and managing disaster prevention and response. Despite some seemingly obvious crossover issues—for example, one would expect land-use agencies to base decisions about zoning or building location in part on access to services and exposure to environmental risk, and water agencies to base their infrastructure development on new urban developments—there is often limited interaction or coordination across agencies associated with these respective domains.

3. Methods

In order to understand the responsibilities of actors and their management of the water system we used a modified Management and Transition (MST) Framework to analyze the different perceptions of management of water in Mexico City (Pahl-Wostl et al., 2010). Within the MST framework specifically, we examined the roles, situated knowledge, and management goals of the actors that define their "action arena" and "action situation", which in-turn impact the actions that actors take in a given system (Mcginnis, 2011; Ostrom, 2011). In the example of hydrological risk in Mexico City, defining the "representations of the world" or "mental models" of actors or sets of actors within action arenas can assist in visualizing the overlaps or gaps in defining problems and actions. These mental models are influenced by the institutions that determine agency mandates, norms, and culture (Pahl-Wostl et al., 2010).

The MST framework focuses on single-sector concerns or issues (water). But, hydrological risk in Mexico City is not captured in the perceptions of actors within the arena of water management alone; rather, it incorporates decisions and perceptions of many different agencies and managers, including those from urban and environmental planning. Thus, our approach was to understand the perceptions and decisions of a diverse set of actors at several operational scales (local,

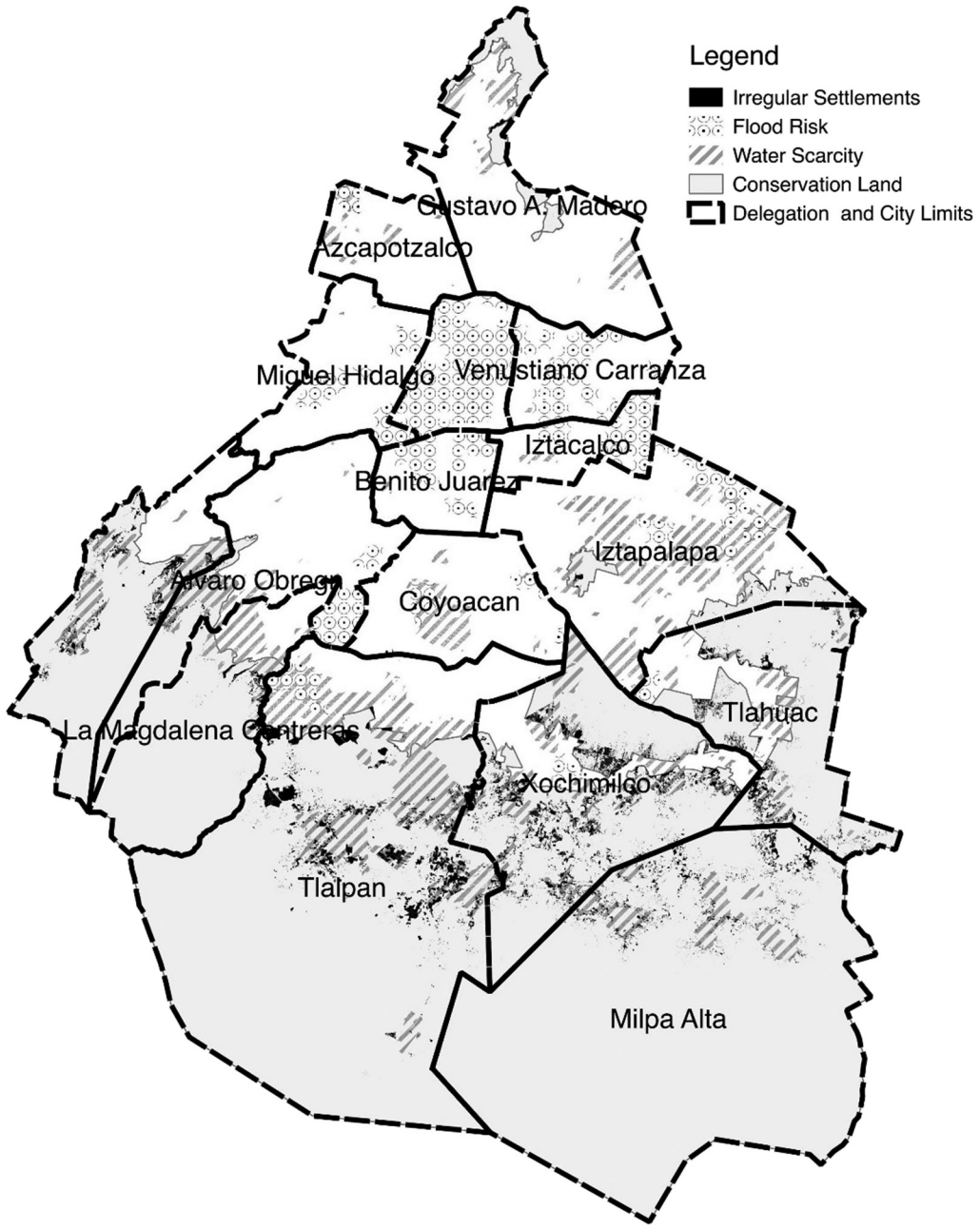

Fig. 1. Informal urban settlement areas, water scarcity, and primary flood zones in Mexico City. Author: Elizabeth Tellman. Sources: PAOT (Conservation Land Zoning), SEDEMA (2016 Mapping of Informal Settlements), CESOP (Digitization of Neighborhoods on the Tandeo System, all included in areas labeled water scarcity), SACMEX (Unidad de Tormenta).

Table 2
Formal water management agencies.

Agency	Scale	Function
DELEGACION DOH (Dirección de Operación Hidráulica Delegacional/ Department of Hydraulic Operation for city boroughs)	City borough	Local management of water services in city boroughs. Operator of local water and sewage systems.
SECRETARIA DE PROTECCIÓN CIVIL Ciudad de México (Secretariat of Civil Protection, Mexico City)	Mexico City	Attends to damage and impacts of hazard and risk in the city through prevention, assistance, rehabilitation, and reconstruction
SACMEX (Sistema de Aguas de la Ciudad de México/Water Commission of Mexico City)	Mexico City	Water operator of Mexico City. Responsible for the operation of water and sewage system
OCAVM (Organismo Cuenca Aguas del Valle de México/Organization of watershed management for the Valley of Mexico)	Regional	Maintains and administers national water in the watershed of the Valley of Mexico (where Mexico City is located)
CENAPRED (Centro Nacional de Prevención de Desastres/National Center for Disaster Prevention)	National	Provides planning and monitoring for natural disaster prevention at the national level
CONAGUA (Comisión Nacional del Agua/National Ministry of Water)	National	Preserves national water resources for its sustainable management and guarantees water security

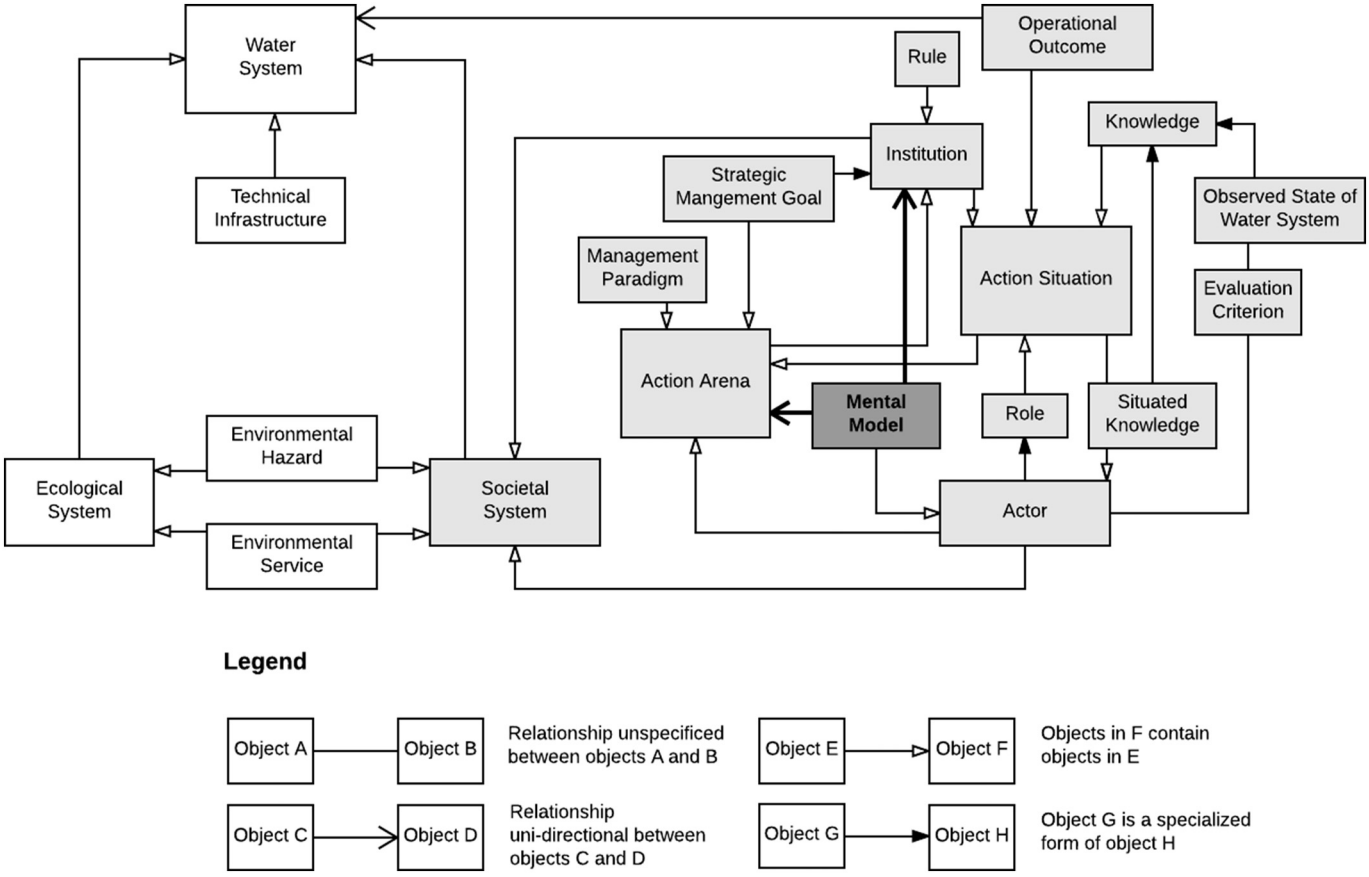

Fig. 2. Modified Management-Transition Framework based on Pahl-Wostl et al., 2010. The light gray boxes are objects of the "societal system", which includes the component of interest in this analysis, mental models. The white boxes include biophysical and infrastructural objects. The links reflect relationships between objects described in the legend (i.e. institutions contain rules).

city-wide, federal) to explore similarities and differences in the perceptions of hydrological risk: those associated with water management, and those associated with land-use change (urban and environmental planning). Fig. 2 shows a modified MST framework in which we add the direct relationship where the object *institution* contains the object of *mental models*. In other words, institutions and rules encompass worldviews and mandates that are reflected in the mental models of actors. Similarly, the object *mental model* encompasses the object of *action arenas*, which shows that the representation of the world according to actors reflect their action arena. This slight modification mirrors the complexity of multiple agencies in which there is a diverse understanding of the problem at hand and the approaches to manage it.

The data analyzed came from 36 semi-structured interviews (14 actors in water management and 22 in land-use management[2]) in which the research team asked actors to explain the issue of water in Mexico City, specifically flooding and water scarcity (including both lack of water and water quality issues). The interviews were structured to follow a mental model interviewing protocol (Cone & Winters, 2011; Morgan et al., 2001), in which actors were asked open ended questions to provoke reflection on what issues regarding water in the city were of most interest and concern to them, what factors they associated with the cause of those issues and what actions they believed should be pursued to address them. The questions in the interviews were open-ended and participants brought up the themes that emerged unprompted. The interviews were conducted over the course of two years, and actors were identified following a stakeholder analysis, in which public agencies were selected according to their mandated interest and influence within the two action arenas (urbanization/land change and water management), as well as the suggestions of subject experts in Mexico City. This interest and influence was validated in the interview process.

The interviews were transcribed and coded for three overall themes: the main problems identified, the causes of the problems, and the reactions and/or actions (including actors and relationships between them). Some related codes were combined for ease of analysis. The coded data was then analyzed through the frequency of codes to understand and visualize the overall perception of the group of actors, including the main causal factors and outcomes of the processes identified. Additionally, we identified the actors' understanding of institutional responsibilities and interactions (or lack thereof). We illustrate how participants frame the problems of hydrological risks by providing illustrative quotes, translated from Spanish by the authors.

4. Results

4.1. Framing hydrological risk

The interviews with the diverse actors in water and land-use management focused on the problem-framing of the general theme of hydrological risk, meaning the participants discussed the main issues they associated with hydrological risk in the city. Fig. 3 shows that water scarcity, flooding, and urbanization were the main problems of concern for hydrological risk. Additionally, the land-use actors included urbanization and lack of housing as part of their problem framing more than water actors, and water actors included flooding, water quality, and

[2] For the water sector, 5 came from federal-level management, 4 came from city-level management, and 5 came from borough-level management. For the land-use sector, 1 came from federal-level management, 10 came from city-level management, and 11 came from borough-level management.

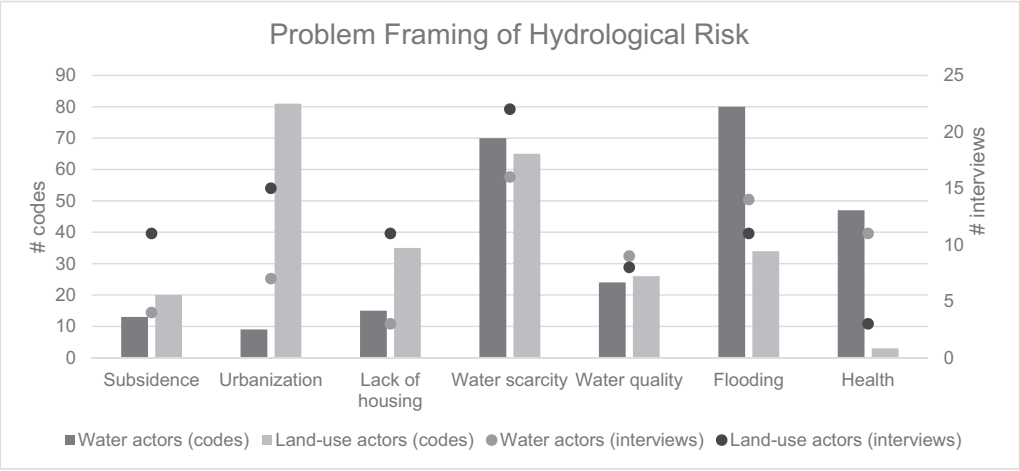

Fig. 3. Framing of hydrological risk by interviewees. The left y-axis and bars show the number of codes in the interviews that refer to the problems mentioned, and the right y-axis and dots show the number of interviews where the codes where mentioned.

health more than land-use actors.

The problem-framing of urban growth and consequently higher water demand was described by actors from both sectors. Actors in the water sector specifically defined the impacts on infrastructure as one of the main problems associated with increased water demand in the city. One actor stated that an important issue with the over-exploitation of the aquifer is the damage to both above-ground and below-ground infrastructure like the metro. Similarly, another actor in the water sector linked the problems of water availability to the need to expand the water extraction network. As one interviewee stated: "*it's a miracle that in this city of millions of people you open the faucet and water comes out… and if the city keeps growing, well we'll always need more networks of water, more and more and where do you get it?*"

As expected, problem framing often reflects the area that the actors manage; for example, several interview excerpts that pinpoint flooding as the main issue of hydrological risk come from interviewees who work at an agency that focuses on flood disaster prevention at the national level. Similarly, framing hydrological risk in terms of lack of housing was most often mentioned in interviews with actors within the Urban Development Secretariat of Mexico City (SEDUVI), whose main function is to design and implement urban plans that include housing.

4.2. Underlying causes and consequences of hydrological risk

The actors associated with land management and urbanization were more likely to cite urban expansion and population growth – particularly *informal* or *irregular* urban growth – as the main cause of hydrological risk (Fig. 4). Urban growth was most often mentioned in terms of informal settlements in the Conservation Zone, but also it was used more broadly to describe the population pressure that the city has undergone over time, which respondents associated with increased frequency of water scarcity and flooding. Urbanization also includes physical land-use or cover change, and the increased impervious surface in the city as it has expanded.

Informal settlements, according to several interviewees, are perceived as illegitimate, environmentally damaging and as forcing the city's hand in water provision. As one interviewee commented, "*these informal settlements have generated a bunch of problems currently, because you are legalizing informal settlements in green or protected areas… you are legalizing physical spaces that capture water for people who illegally took that space.*" But under the Water Law of Mexico City (formally known as the Ley de Aguas del Distrito Federal, 2003), all residents have the right to water. The controversy in providing services to informal areas plus the difficulty in transporting water in trucks ('*pipas*') are the main reasons that informal settlements have intermittent water access. Indeed, one actor from the water sector stated that "*In the strict sense no one has to provide services to informal settlements, not drainage, nor electricity, nor water, but… as long as they do not get rid of them they have to give them services…*" A local interviewee also reflected on this reality while describing how specific informal residents are on a list to get a limited amount of water, which was not too much as to not encourage more informal urban expansion.

Participants described several processes by which informal settlements occur, one of which is the informal division of communal or ejido property, and sale of plots for housing, often in risky areas along embankments. In other circumstances, intermediaries "sell" land that does not have title or where the legal situation is ambiguous, responding to the demand for more affordable housing than what is available in formal land areas in the city core. In this sense, hydrological risk is tightly linked with informality and inequality, with areas where they "waste" water and others where "they don't have a drop." Additionally, informal growth results from clientelism (an exchange of votes for public goods like urban services (Hicken, 2011), discussed below) and overlapping or gaps in government-agency responsibilities, which are reflected in the comments from participants from the land-use sector regarding government management (clientelism and corruption).

As seen in Fig. 4, actors in the water management sector were more likely to describe the causes of risk as an issue of hard infrastructure. In terms of flooding, one interviewee from the water management sector noted that the main cause of flooding was trash blocking drains in the city. Trash collection, according to the interviewee, is the responsibility of the city boroughs, but they do not effectively manage trash removal, which leads to drainage pipes being blocked, which then leads to flooding. Another participant from the water sector described how the city's main drainage channel no longer had the gravitational force to send water out of the city (because of subsidence), which has led to the city investing in more infrastructural projects to pump water out to avoid flooding, which is essential during the rainy season.

4.3. Sectoral responsibilities

As expected, the interviews illustrated that there is a clear division of responsibilities between agencies in land-use related themes and those in water management. Actors in urban development and environmental protection tend to focus on urbanization/housing and watershed protection, respectively, as their main responsibilities, whereas actors in the water sector focus on infrastructure and water availability throughout the city. These divisions, however, cause tensions as actors in both action arenas acknowledge that the reality of both urban growth and hydrological risk are intricately linked. As one

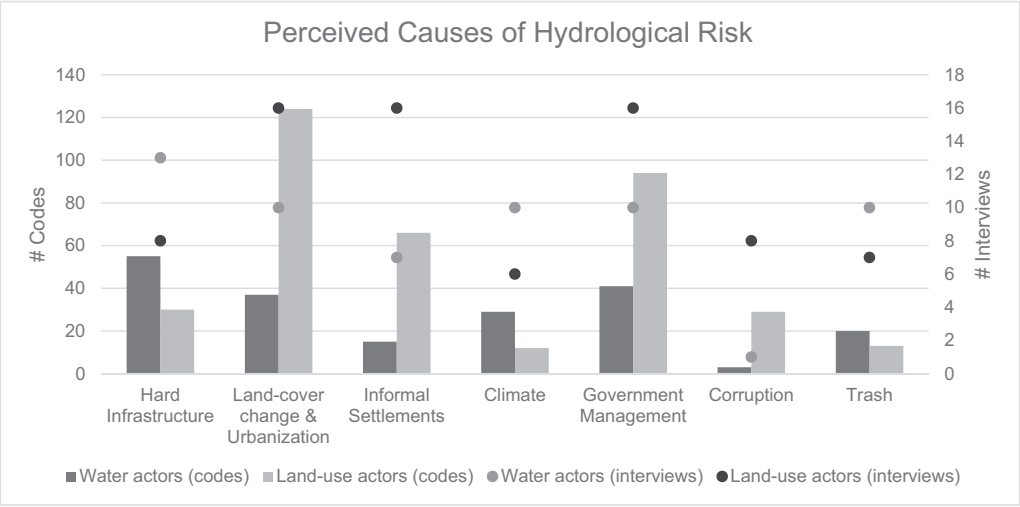

Fig. 4. Perceived underlying causes of water scarcity and flooding, according to interviews. The left y-axis shows the number of codes in the interviews that refer to the specific causes associated with the bars, and the right y-axis shows the number of interviews that refer to the causes.

interviewee in the water sector stated, "*the urban development projects that the national government creates do not consider the investment in hydrologic infrastructure, so subsequently the communities suffer problems of water scarcity and flooding.*" This statement illustrates the difficulty in dividing responsibilities along sectoral lines when managing for water scarcity and flooding. Similarly, another actor in the water sector noted:

> "*there is a lack in communication between institutions, for example…a meeting we had where the Secretariat of Urban Development said that 'we can't contain growth, that's our position'…but our response is that another issue is water consumption, with more people we will have less availability of water…*"

Despite their assertion that urban growth and informal settlements were responsible for hydrological risk, the interviewees had little agreement on who should be responsible for confronting the issue. While SEDUVI, together with local borough agencies, oversees urban planning and housing, it is concerned with formal developments within the city core, and it was unclear from the interviews who should be responsible for managing the informal settlements. One respondent stated that in 2014 the responsibility for regulating the informal settlements shifted from SEDUVI to SEDEMA, which in turn has created a "bunch of problems" as these settlements continue throughout the conservation area. But in the end, it is unclear who really should be regulating informal settlement growth. As one interviewee stated, "*It has not been possible to regulate or control the growth in some areas, because there is no mechanism to form a physical barrier when it comes to informal settlements… The demand for housing is stronger than the desire to contain* [*the growth*] …"

According to the interviews, SEDUVI does consider water availability for the building of formal housing projects, mostly in the inner-city core. For these development projects, there are limits on housing density according to the available amount of water, since, as one respondent from urban development commented, "*the theme of water is a sensitive one in the city.*" If a developer wishes to increase the approved housing density, he or she needs to submit plans to SEDUVI for accommodating the increased demand and pressure on the hydrologic infrastructure. It is not clear the extent to which SACMEX participates in the approval of such remediation plans. One actor in water management commented that "the division of labor" between institutions is at the root of the tension:

> "*while some* [*institutions*] *are focused on development because they see it as one of their goals, I think there isn't adequate coordination so that an institution, for example that is responsible for water, has authority and can just say 'no more urban development' because there isn't any* [*water*] …"

4.4. Cross-scalar actors and actions

The regulation of urban growth and the provision of services become more complicated with the division of responsibilities between the city government and the borough governments. Boroughs have their own urban development plans and are often intermediaries between service providers (i.e. SACMEX) and residents. Specifically, SACMEX provides the formal water services in the main water and drainage lines, while boroughs tend to the secondary lines that are smaller and often harder to maintain with regularity. The borough governments also act on behalf of the residents in informal settlements, organizing water delivery in trucks from SACMEX. But these relationships have often resulted in clientelism, as delegations provide services in exchange for political support. For example, one interviewee explained that "*basically the boroughs end up* [*formally*] *urbanizing the settlements*", since they provide services to avoid confrontation with the local population and in order to secure votes. As soon as a settlement has water, the interviewee explained, "*it consolidates and things become formalized.*"

At the same time, the boroughs must submit their local urban development plans to the city urban development secretariat, SEDUVI, and are also involved in giving permits for construction and provision of services. This makes the role of boroughs instrumental in water and urban growth, despite not having official regulatory power at the city level. However, the borough governments have rapid turnover: officials are replaced every three years. That means that even despite the best intentions, borough officials are often more focused on winning elections and gaining support from residents, informal or not, rather than long-term planning. The result, according to the interviewees, is that urban development "plans" at the borough level are reactive, rather than proactive. As the local government shuffles in and out rather quickly, their plans reflect the evolving reality instead of being instruments of long-term planning.

5. Discussion

The case of water risk management in Mexico City demonstrates how the sustainability challenges of today's cities easily fall through the cracks of formal and informal organizations, sectoral boundaries, and levels of urban organization and management. The complex

interdependencies of urban growth patterns, development initiatives, water resource availability, and risk are evident to all the actors involved. Yet in the face of such complexity, sectoral actors appear to define their mandates narrowly and minimize issues or processes that their agencies manage or directly influence, such as the availability of affordable housing, clientelism, or defending the right to water. Instead, in our interviews sectoral actors focused on factors that they perceive to be beyond their own capacity or responsibility: uncontrolled and informal settlements, irresponsible behabior of residents, and failtures of (other) sector agencies.

5.1. Defining governance gaps in the management of hydrological risk

Hydrological risk in Mexico City thus reflects an uneven landscape where potentially overlapping or unclear mandates in formal governance lead to informal urban growth and therefore hydrological risk, and the rights to the city and to water are tenuous. Defining the narratives and framing of hydrological risk by actors in management agencies assists in understanding how these narratives feedback into mandates and lead to gaps. Our analysis shows that managers in the city perceive water and urban development as tightly linked, despite their different perceptions of the issues of scarcity and flooding in the city. As Widdifield and Banister note, regarding their analysis of the history of water in Mexico City, the "rhythms of daily life, politics of land use and development, modes of technology and urban infrastructure-have long been tightly bound to hydrologic processes…" (2011). Our interviews echo this observation, as actors from different institutions reflect on the politics and policies (or lack thereof) that are instrumental in the city-wide presence of hydrological risk.

Yet, while the interviewees consistently recognize the interdependence of urban growth and hydrological risk, they characterize the processes of vulnerability production as exogenous to their mandates and control. The participants discussed urbanization as an external problem, one that is out of control with no form of remediation. According to this narrative, the demand for housing leads to price increases, and the poor have little choice but to settle in informal settlements. This is a common discourse, as cities—particularly in the Global South—are rarely planned or constructed with the urban poor in mind, and both public and private sector solutions have largely failed (Mcgranahan, Mitlin, & Satterthwaite, 2008). The lack of affordable housing with access to basic services perpetuates and externalizes risk to populations with no other option but to live with hydrologic vulnerability.

As a result of this narrative and associated reality, the residents themselves are both blamed for and must cope with the burden of scarcity and flooding. Public agency actors such as those we interviewed have created a discourse in which they are implicit victims, overwhelmed by these dispersed and uncontrollable citizen actions: informal settlement expansion, illegal trash disposal and political pressure for services. While public sector actors have insight into the complexity of risk and vulnerability, they implicitly and explicitly define vulnerability's dynamics to limit their responsibility to act or intervene.

The issue of lack of water service in informal areas is not just a problem in Mexico City; it is repeated in global cities throughout the world, including Dehli, Jakarta and other cities in the Global South (Bakker et al., 2008; Kooy, 2014; Srinivasan et al., 2013). These cases show that despite good intentions of providing universal access to water—at the urban scale, as well as internationally through the Sustainable Development Goals—so long as informality is not addressed, it seems tenuous that this goal will be met.

5.2. Governing the ungovernable

The persistence of water scarcity and flooding in Mexico City illustrates what Swyngedouw, 2009 has termed a problem of "poverty and governance" in discussing water scarcity in many cities of the global south. Different agencies have either overlapping or unclear formal responsibilities for ensuring adequate housing with water supply and without the risk of flooding. In the case of the informal settlements in the Conservation Zone (SC), management is actually "over-regulated" which leads to fragmented and inconsistent management, and opportunities for informal settlements to occur (Aguilar & Santos, 2011).

Therefore, there exists an effective "governance failure" (Bakker et al., 2008) in the provision of services to peripheral—and often informal—settlements of Mexico City, where no formal sector manages water supply for poor households. This leads to "poverty traps," where the welfare of poor households is exacerbated by constant flooding and/or water scarcity (Eakin et al., 2016). While some cities in similar circumstances turn to the private sector for service provision, in Mexico City the city's water commission (SACMEX) still controls most water provision. The debate of "institutions/ownership," however, shows that it is not possible to predict the efficiency of water distribution based on either state or private forms of management (Bakker et al., 2008). The non-state solutions often come from the residents themselves, as they cope with persistent hydrological risk by buying bottled water, organizing themselves in the face of floods, and assuming the consequences and burdens of governance gaps (Eakin et al., 2016).

The absence of state solutions over time also has given way to the power of intermediaries, such as water deliverers (through trucks and pipes), dispatched by the borough or city water authority, or sometimes through informal mechanisms (de Alba, 2017). These intermediaries offer short-term solutions and are even considered to be ways to provide services until formal infrastructural networks are concretized in informal settlements (Kooy, 2014). However, in Mexico City and much of the Global South, informal water services do not necessarily satisfy service needs and demands while formal infrastructure becomes established; rather they become part of the "politics of water," where certain sectors of the city remain persistently underserved (*ibid* 2014).

5.3. Urban growth: asking for forgiveness rather than permission

Implicit in the discourse of both land and water management officials at all levels of government is a causal chain, which rarely receives direct attention: formal urban development policy plays a significant role in driving informal urban growth, and thus the geographic and social distribution of hydrological risk. In the context of rising land prices in the urban core, formal initiatives for low-cost housing are occurring at the urban periphery; service provisioning is an afterthought or relegated to underfunded local government (Aguilar & Santos, 2011). Other scholars have pointed to the dynamics of land speculation: developers collude with politicians to build homes on cheap land far from the city with no services, and profit from capital gains and increases in land value when the city borough or municipality is pressured by residents or the developer to provide urban services (Eibenschutz Hartman & González García de Alba, 2010; Salazar, 2014). This speculation drives urban patterns at the northern fringe of the metropolitan area.

As is the case in other large cities in the Global South, the government in Mexico City has taken a reactive position toward irregular settlements, promising to give title after residents have settled on properties along the periphery (Aguilar & Santos, 2011). At the southern fringe (the conservation zone), regularization of communal agrarian land allows irregular settlements to become incorporated into and adjusted to the borough's zoning plans. In both formal housing and the regularization of informal housing, settlers and developers ask for forgiveness *after* constructing homes, rather than asking permission beforehand. Thus, urban plans are updated to reflect the urban reality, instead of used as a tool to define were urbanization should actually occur, and issue permits for development on that basis. Instead of preventing urbanization in the conservation zone or removing homes,

many boroughs turn a blind eye and some politicians even promote settlement or land invasion to gain votes. These same politicians may even carry forth the regularization process.

Informal settlers are often blamed as “the problem” in urbanization and hydrological risk, which was a common discourse among city managers of both land and water institutions. Yet the very expansion of informal settlements occurs because the poor cannot access credit to buy homes in the formal sector. Social and political actors often take advantage of this unfulfilled demand to promote settlement in informal areas to make money or gain votes. Informal settlements become the scapegoat for environmental degradation, even though the production of vulnerability and hydrological risk may be rooted in more powerful actors, including land and water agencies, which current formal institutions are failing to address.

6. Conclusions

The case of water and land-use management in Mexico City illustrates the disconnect and mismatch between the perceptions and responsibilities of management sectors, and the difficulty in managing for hydrological risk in the face of uncontrolled urban growth. The interviewees largely see urbanization as exogenous and particularly with the case of irregular settlements, beyond the direct control of one particular agency. Overlapping and ambiguous responsibilities between several institutions exacerbate the challenge, specifically in the southern portion of the city (the Conservation Zone), where most of the irregular urban growth takes place.

Ironically, in the discourse of the interviewees, it is the formal agencies who are victims, bullied by the politics of decision making at other levels of government, and by citizen-level processes considered exogenous to the agencies' mandates and ungovernable. As victims of and respondents to urbanization, rather than active participants in its complex dynamics, land and water agencies reinforce and institutionalize social patterns of vulnerability.

Currently, the formal action arena for water risk management in Mexico City is too narrow to address the challenges of hydrological risk; the relevant actors are either not participating in water and/or land governance, or are defining their involvement in ways that are either externalizing (in the case of the urban development sector) or internalizing the burden of risk (in the case of the city's poorest residents). Innovation in the governance of urban hydrological risk is clearly needed (see OECD, 2012). Effective governance requires the acknowledgement of the roles that formal institutions and agencies play in the production of vulnerability, and the tight coupling between urbanization and hydrological vulnerability, potentially assisted through a Governance Capacity Framework (Koop et al., 2017). The categories of informal/formal and core/periphery create fissures where bridges are needed. Actors from the land and water sectors must grasp the interconnectivity and interdependence of their mandates and problem domains.

In collaboration with the residents who are coping daily with scarcity and flooding, and the intermediaries who fill the voids left by formal institutional arrangements, a new “action arena” could be formed in which cross-scale and cross-sectoral learning and novel governance of risk could emerge (Pahl-Wostl et al., 2010). The case of Mexico City illustrates the need for new and innovative governance structures that can be more flexible in nature and integrated in practice, and that recognize the need to integrate water management and urban planning that occurs both formally and informally, perhaps through an “additional tier” of government (Ward & Robles, 2012). Closing the governance gaps presents challenges, but it is needed to manage hydrological risk in the city.

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